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ANOPHELES CRUCIANS.

HABITS OF LARVÆ AND ADULTS.

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In the course of malaria investigations conducted in Alabama during the summer of 1918 the writer was afforded an exceptional opportunity for the study of *Anopheles crucians* Wied. Since this species is in many respects the least known of the three anophelines (*punctipennis, quadrimaculatus* and *crucians*) common to the gulf coast region of the United States a particular effort has been made to obtain as much information as possible regarding the phases of its habits and characteristics that might have any bearing on the malaria problem. In this category may be placed such features as the food habits of larvæ and adults, the choice of breeding places, seasonal distribution, range of flight and selection of hiding places. Each of these subjects has received as much attention as circumstances would permit.

Description of Environment.

Before considering the data in detail it will be necessary to describe briefly the main features of the territory in which the investigations were made, for the most interesting observations are intimately connected with the physical peculiarities of the environment.

About 2 miles west of the outskirts of Montgomery, Ala., was [1] a shallow swamp, about 3 miles long and from a few feet to 200 or 300 yards wide, running in a north and south direction. This swamp occupied a natural watercourse, which during the rainy season had a sluggish flow, but which later dried up into a series of shallow, isolated puddles. Throughout most of its length the swamp was heavily wooded, but in parts it was open and grassy, thus affording a wide range of conditions. At the lower end the waters suddenly converged into a narrow channel, where, in the spring, the flow was rapid through a winding course to the river. Under ordinary conditions the waters of the swamp proper were clear and practically free from algæ, etc., although the bottom was covered with a mat of dead leaves from the thick foliage overhead.

Into the swamp near its upper end, as shown in the accompanying map, flowed a small ditch, carrying refuse from a chemical factory in which sulphuric acid was manufactured. The waters of this ditch were impregnated with chemicals to such an extent that the ground and the débris in the swamp were plainly discolored for a considerable distance. The discoloration was, of course, progressively less noticeable below the ditch inlet, but it extended almost to the end of the swamp in the sections where the water was deepest and stood longest.

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[1] Conditions are now materially altered by drainage and other antimosquito measures.

To the east of the swamp lay a stretch of open and almost level country, sparsely settled by negroes and a few whites. Further east, at a distance of about 1½ miles, the population increased as the outskirts of Montgomery were approached.

Throughout this general area and the territory bordering it several small ditches, puddles, etc., were scattered here and there, but present interest is centered primarily in the above-described swamp.

This swamp was first observed on April 13, at a time when the weather had not yet warmed up after the exceptionally cold winter preceding. Temperature records for the week ending April 13 show a maximum of 67 and a minimum of 35° F., with a mean of from 40 to 59. Little if any breeding had been observed elsewhere in the region up to that time, but in spite of the temperature the waters of the swamp were found to be literally covered with *Anopheles* larvæ, many of them nearly full grown. Pupæ were also present, although no collections were made at the time to determine whether or not they were *Anopheles*. The writer has never observed such prolific *Anopheles* breeding in any other place. The larvæ were seemingly everywhere—in the shade, in the sun, in among the grasses and bushes, and out in the open water—without any apparent discrimination. And collections made subsequently showed them to belong to only one species—*Anopheles crucians*.

From April until August this swamp was kept under observation and a large number of larvæ and pupæ were collected for identification or for experiments. These collections continued to give nothing but *crucians*, save for occasional specimens of *Culex*, that became more and more numerous as the warm weather came on.

Careful collecting for several miles around this area failed to indicate the breeding of *crucians* in any place other than the above described swamp, although with the advent of warm weather both *punctipennis* and *quadrimaculatus* were found here and there throughout the territory, even up to within a few feet of the swamp. It was evident, therefore, that the waters of the swamp possessed some peculiarity favorable to *crucians* but repellant to the other two species. Of course, the chemical wastes emptying into the upper end of the swamp were at once suspected, and the results of subsequent investigation leave little doubt that they were the determining factor.

The various lines of evidence pointing to this conclusion, together with data relative to the particular effects of the chemical contamination, may be summed up as follows:

A. CHEMICAL CONSTITUTION OF THE WATER.

An analysis of a sample of the swamp water taken in August gave the results following.

	Parts per million.
Total residue on evaporation (180° C.)	398.5
Calcium (Ca)	14.6
Magnesium (Mg)	12.8
Iron (Fe)	.9
Aluminum (Al)	6.7
Sodium (Na)	75.5
Potassium (K)	17.8
Silica (SiO_2)	37.2
Sulphate (SO_4)	184.8
Chloride (Cl)	21.3
Ammoniacal nitrogen	.08
Organic nitrogen	.23
Nitrogen as nitrite	.00
Nitrogen as nitrate	.28
Total acidity (phenolphthalein)	104.0

Since this sample was taken at a distance of nearly 2 miles from the source of contamination and at a time when the waters in this part of the swamp (the lower end) were diluted with rain water, the analysis probably represents almost the minimum, rather than the maximum, concentration of the contaminating chemicals. As may be seen, the water is acid and has a high content of sulphates, sodium, potassium, iron, and aluminum.

B. VISIBLE EFFECTS ON THE SWAMP ITSELF.

The discoloration of the soil and débris in the swamp has already been mentioned.

C. GENERAL EFFECTS ON LIFE IN THE SWAMP.

1. *Gross vegetation.*—At the ditch inlet small trees and bushes were dead or noticeably affected for a few yards. Otherwise the gross vegetation appeared to be normal.

2. *Aquatic vegetation.*—Practically no aquatic vegetation was to be found, except traces of green algæ here and there.

3. *Fish.*—Fish were entirely absent, although they had free access from several sources. Ditches and small ponds adjacent to and connected with the swamp were full of fish (*Gambusia* and perhaps others).

Experiments showed the water to be poisonous to fish. Eleven healthy specimens of *Gambusia* put into a jar of water freshly taken from the swamp died as follows: At the end of one hour, 3 dead; at the end of three hours, 10 dead; at the end of five hours, all dead.

Control specimens lived in a similar jar of uncontaminated water for several weeks.

Other specimens put into pools in the swamp all died within a few hours.

4. *Aquatic insects.*—In the spring aquatic insects were practically absent, probably because of the cold weather, but later numerous forms, such as the Dytiscids, Gyrinids, dragon-fly larvæ, damsel-fly larvæ, etc., appeared in normal numbers.

5. *Microscopic fauna and flora.*—Microscopical examination of the swamp water indicated a decided scarcity of Protozoa, rotifers, unicellular algæ, etc., compared with other bodies of water in the vicinity.

D. EFFECTS ON THE LARVAL FOOD.

Since little is known respecting the essential food of *Anopheles* larvæ this subject can only be treated in a general way. The evidence is particularly interesting, however, in the light it throws on the food habits of *A. crucians*.

Considering the fact that *crucians* was propagating in enormous numbers it is evident that the food supply was of a suitable nature and at least fairly abundant. It seems hardly possible that the scanty microscopic fauna and flora in the water could have provided this food supply, and attention is drawn to the only other material in evidence—a relatively large amount of what appeared to be disintegrated plant tissue. The water was rich in minute, microscopical particles of this colorless, but evidently organic material. It is very strongly suggested that this furnished the bulk of the food for the prolific development of larvæ.

Apparently this disintegrated material was derived from the mass of dead leaves covering the bottom of the swamp, and it seems probable that its abundance was the result of chemical action caused directly or indirectly by the chemicals emptied into the swamp from the chemical factory.

If these deductions are correct it would appear that *A. crucians* can subsist in nature on a diet made up primarily of nonliving vegetable matter. That it will do this in the laboratory is certain from experimental evidence to be published at a later date.

Habits of the Adults.

Under this heading may be considered the choice of breeding places, seasonal distribution, range of flight, and local distribution with reference to human habitations.

A. CHOICE OF BREEDING PLACES.

It is impossible to state whether the chemical properties of the swamp waters possess an attraction for the egg-laying females and the abundance of *crucians* is due to this factor, or whether the females lay their eggs indiscriminately and their development in the contaminated water is due to the peculiar properties of the latter being especially suited to the eggs and larvæ of this species. One is tempted to suggest the former, in view of the sharp limitation of *crucians* to this one particular swamp, but there are no actual observations to indicate that *crucians* eggs were not laid in adjacent waters.

Certain experiments were made, however, to test the ability of *crucians* larvæ to develop in waters producing other species, and the ability of *punctipennis* and *quadrimaculatus* larvæ to develop in the swamp. These were as follows:

Cages of fine wire gauze were put into the swamp and into uncontaminated waters near by. In the former were put larvæ of *punctipennis* and *quadrimaculatus* taken from fresh water, and in the latter were put larvæ of *crucians* from the swamp. Likewise the same sort of test was made in the laboratory in artificial containers.

In the former case *punctipennis* larvæ were able to live side by side with *crucians* in the swamp water, and at least one *punctipennis* adult was hatched out. Vice versa, *crucians* larvæ were able to develop in waters outside of the swamp. In this case the cage had an open top, to make conditions as nearly normal as possible, and it is not known whether the specimens hatched, but it is certain that some reached the pupal stage. Similarly in the laboratory *punctipennis* larvæ developed from the newly hatched stage to maturity in water from the *crucians* swamp, changed daily. Five *punctipennis* adults hatched from one such culture. To a lesser degree *crucians* larvæ developed in uncontaminated water. Apparently their development was retarded, since only one adult was obtained from about 20 larvæ, and many larvæ failed to pupate. It is possible, of course, that this failure to develop may have been due to some other cause than the difference in water, but no such cause could be detected.

In this connection it should also be noted that the effectiveness of the swamp waters in favoring the development of *crucians* at the expense of other species became less marked as the channel was followed away from the swamp proper. This of course varied to a considerable extent with the amount of water in the swamp and channel. Early in the season, when the water was flowing in large quantities, that in the channel was practically the same as that in the swamp, but later, when the flow stopped and the pools in the channel were fed mainly from rain water that had not come from the swamp, it was observed that *punctipennis* and *quadrimaculatus* as well as *crucians* bred in the pools. All three species were hatched from larvæ collected in the channel about half a mile below the swamp outlet.

These facts when considered together, suggest that the discrimination between breeding places, on the part of *crucians* as distinguished from the other two species, is not entirely due to the inability of the larvæ to develop in the less favored places. Although the water in the unfavorable places apparently does have a detrimental effect on development it does not entirely prevent it, and it seems not improbable that the determining factor in nature is either the selection of "favorable" places for egg laying, or else a direct effect of the water on the eggs—that in the "unfavorable" places destroying them before they hatch. There is room for considerable more investigation on this point, however.

B. SEASONAL DISTRIBUTION.

In the locality under consideration *crucians* appears early in the season (first week in April or earlier) and continues breeding until late summer and possibly fall. At the time the observations were discontinued (late August) they were still breeding in the swamp, wherever there was water.

It is to be noted that this observation of *crucians* breeding prolifically early in April is somewhat at variance with the records of other observers who have found *crucians* to be mainly a fall and winter breeder.

C. RANGE OF FLIGHT.

During June and July efforts were made to determine the range of flight of *A. crucians* from the swamp toward the city of Montgomery. Collections were made in and around buildings at distances varying from 500 to 10,000 feet in the region lying between the swamp and the city. An attempt was made to check these observations by means of stained specimens according to the method used by Le Prince at Panama, but owing to unavoidable delays this part of the work was begun late in the season, after much of the swamp had been drained, and the number of mosquitoes available for staining was too small to give reliable results. Consequently the data presented here are from unstained specimens. It seems very probable that all of these specimens actually came from the swamp, and that the distances recorded represent actual ranges of flight, for our collections of larvæ failed to reveal the presence of *crucians* anywhere in the region except in the swamp. But the possibility that a few specimens might have been derived from some other source casts some doubt on the reliability of the extreme records where only one or two specimens are involved. However, there can be little question as to the significance of the data as a whole, and it is believed that they give a good idea of the general dispersal and range of flight for the species.

The principal data are best shown by the accompanying chart and tables. In comparing these it should be noted that emphasis was placed on collecting at distances of more than 3,000 feet, since it was obvious that specimens were very numerous at shorter distances.

As a result the records from the greater distances, although giving smaller numbers of specimens, really represent the results of longer and more careful search than those from shorter distances. A particular effort was made to inspect thoroughly at the extreme outer range, beyond 9,000 feet. The fact that only three specimens were found at distances between 9,000 and 10,000 feet, among 24 buildings examined, and that none was found over 10,000 feet from the swamp, not only serves to limit the range of flight, but gives further indication that few if any sources of crucians existed outside of the swamp.

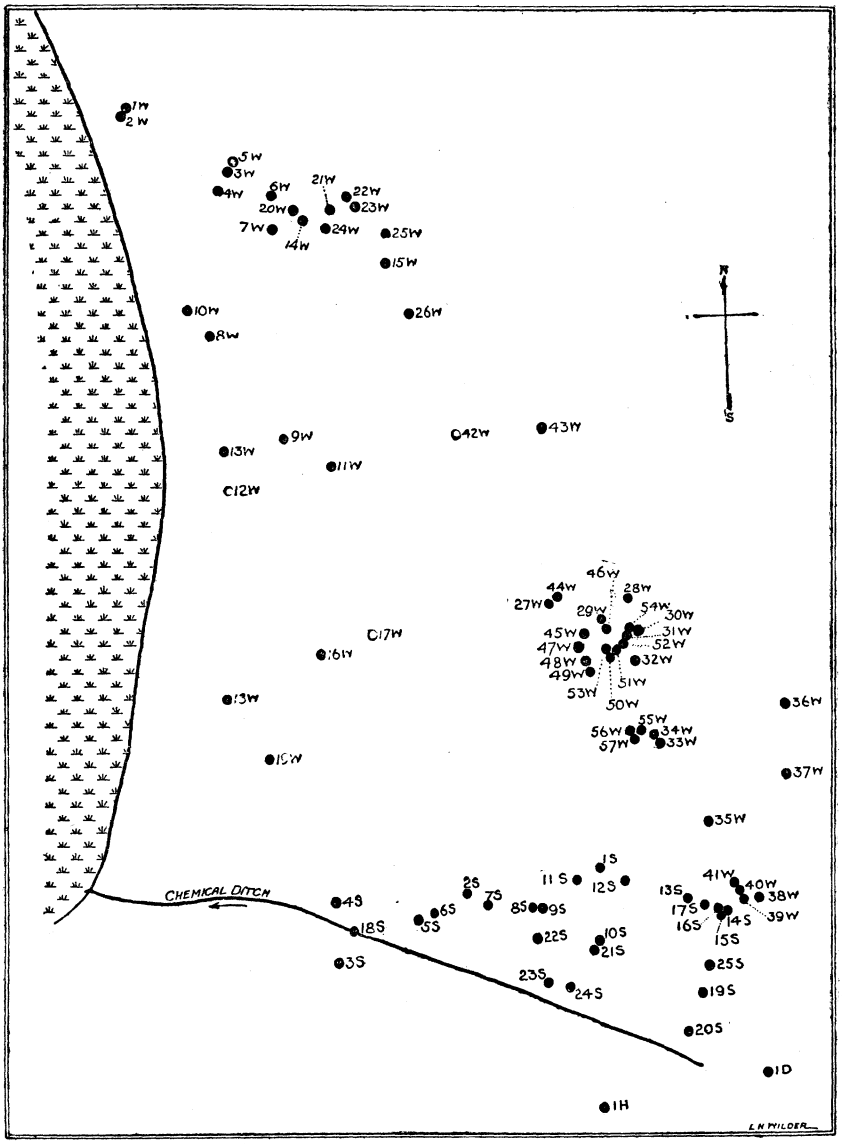

Table 1 gives the data in detail, arranged in such a way as to indicate the approximate distance from the swamp, the number of specimens taken from each station, the nature of the places in which the specimens were found, and the number of buildings examined in each case. A station usually represents a collection of buildings close together, such as a dwelling and its various outhouses, or two or three dwellings that happen to form a group. Each station is numbered in the tables and on the map, to facilitate comparison. The distances were obtained by survey, and are believed to be as accurate as is necessary for the purpose—i. e., to within about 100 feet.

TABLE 1.—*Showing flight of Anopheles crucians from breeding grounds.*

NOTE.—The stations (consisting usually of a group of buildings) are arranged according to distance from the swamp, and the records are classified to indicate the nature of place from which the specimens were taken. Records of *punctipennis* and *quadrimaculatus* are given in parentheses—e. g., (2p, 1q) following the record of *crucians* from the same place.

Station number.	Under house.	In house.	In barn.	In pig-pen.	In privy.	In shed.	Total.	Number buildings examined.	Distance from swamp.
									Feet.
1W	6						6	1	750
2W	143 (2p,1q)						143	2	550
8W	7						7	1	850
10W						27	27	1	750
12W	27*		36				63	2	1,000
13W	11						11	2	850
3W			1	18			19	6	1,700
4W	17						17	3	1,650
5W							0	4	1,850
9W	10						10	1	1,750
18W	8	1		2			11	3	1,500
19W	13		16			6	35	4	2,000
6W	1						1	2	2,350
7W							0	2	2,250
11W	26						26	2	2,500
14W	4						4	3	2,750
16W	18 (1p)						18	1	2,750
20W	3						3	3	2,600
15W	8 (2p, 6q)						8	2	3,750
17W	10						10	1	3,500
21W	3						3	3	3,250
22W							0	3	3,350
23W	1						1	1	3,500
24W	7 (2p)		8			4	19	7	3,100
25W	1 (1p)						1	3	3,750
26W	7 (2p, 4q)		1				8	6	3,850
3S	13		3			3	19	4	4,000
4S	20 (1p, 1q)						20	4	3,750
18S	[1]						35	1	4,000
42W			4				4	2	4,350
5S	5					1	6	6	4,850
27W	1 (2p)						1	5	6,000
43W	1						1	1	5,750
44W	1						1	4	6,000
2S	2						2	2	5,500
6S	3						3	2	5,100
7S	2						2	1	6,000
29W	2 (2p, 4q)						2	5	7,000
45W							0	3	6,750
46W							0	4	7,000
47W	1						1	4	6,500
48W							0	3	6,750
49W							0	1	6,850
50W							0	2	7,000
51W							0	2	7,000
8S	7 (4q)	1 (2q)				3 (1q)	11	4	6,500
9S	2 (2q)	(5q)	40 (3q)				42	5	6,600
22S	2						2	1	6,750
23S	1 (1q)						1	3	7,000
28W							0	3	7,250

[1] Under bridge 35 (2p, 1q).

TABLE 1.—*Showing flight of Anopheles crucians from breeding grounds*—Continued.

Station number.	Under house.	In house.	In barn.	In pig-pen.	In privy.	In shed.	Total.	Number buildings examined.	Distance from swamp.
									Feet.
30W							0	2	7,500
31W	1						1	4	7,350
32W	1 (1p)						1	4	7,400
52W							0	1	7,250
53W	1 (1q)						1	1	7,100
54W							0	3	7,350
55W							0	4	8,000
56W	(1q)						0	5	7,850
57W							0	2	7,850
1S	2 (1p)					1	3	14	7,500
10S	1				1		2	2	7,650
11S			1				1	4	7,250
12S	1						1	5	7,850
21S							0	2	7,500
24S			1 (6q)	4 (1q)			5	9	7,350
33W				1 (1p)			1	4	8,250
34W	2 (2p)						2	3	8,200
35W	4 (1p)					(1p)	4	5	9,000
13S	1						1	3	8,850
17S							0	4	9,000
1H	4 (2q)						4	2	8,500
38W			(1q)				0	2	9,850
39W	(1q)						0	2	9,750
40W							0	3	9,750
41W	1 (1p)						1	2	9,700
14S							0	4	9,350
15S							0	3	9,350
16S							0	2	9,100
19S	1						1	3	9,350
20S							0	2	9,250
25S	1						1	1	9,350
36W							0	1	10,000
37W							0	3	10,000
1D							0	1	10,750

In comparing the records, it appears at once that certain types of hiding places are much more favorable than others, a fact that has considerable effect on the distribution. For instance, a stable or pig pen, if suitably constructed and in use, generally harbors more *crucians* than other buildings much nearer the swamp. Another feature to be noted is the apparent attraction of the ditch leading from the chemical factory to the swamp.[1] The distribution suggests that some of the mosquitoes follow up this ditch from the swamp and then spread out over the adjacent territory. An alternative explanation is, of course, that another source of *crucians* existed south of the ditch, causing an influx from this direction, but no such source was found. That *crucians* did not breed in the ditch itself is practically certain from the fact that the acid in the ditch was so concentrated as to destroy rubber boots and other organic products, and from the fact that no larvæ of any kind were ever found in the ditch.

Reviewing the general features of the data on flight range, the following conclusions appear to be warranted, pending more exact evidence from experiments with stained specimens:

When breeding in large numbers, *crucians* will become distributed over an area within approximately seven thousand feet of the source, in numbers sufficient to be of sanitary importance. From seven thousand to nine thousand feet the menace will be questionable, probably depending on circumstances, and at more than nine thousand feet it will be negligible. The latter two conclusions, since they are based on the absence rather than presence of the mosquitoes, may be considered reliable in so far as they limit the zone of sanitary importance. The zone may be narrower, but it can not be much wider than that indicated, except where topographic or other features make the situation essentially different from that under consideration.

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[1] Note the larger catches at points near the ditch, e. g,. stations 18S, 8S, 9S.

So far as is known, winds had no effect on the distribution in the present case. There were no prevailing winds during the period of observation, and the occasional gusts produced no noticeable effects on distribution.

D. DISTRIBUTION WITH REFERENCE TO DWELLINGS—CHOICE OF HIDING PLACES.

As indicated by the data in Table 1, *crucians* shows very little tendency to choose dwelling houses for hiding places in the daytime. The great bulk of the specimens were found underneath the houses or in stables, pig pens, etc. In this respect *crucians* seems to resemble *punctipennis* rather than *quadrimaculatus*. In the table the catch of *quadrimaculatus* and *punctipennis* is given in parenthesis side by side with that of *crucians* to indicate the relative abundance in the different types of hiding places. It is significant to note that out of the 634 *crucians* only 2, or three-tenths of 1 per cent, were found in dwellings, while of the 48 *quadrimaculatus* 7, or 14 per cent, were found in dwellings. All of the observations on *crucians* point toward the same conclusion in this regard. It was found that stables or pig pens, if in use, even when situated a quarter of a mile or more from any dwellings, were obviously favored by *crucians* and that damp places near the ground—underneath houses, under bridges, etc.—were given preference over the interior of habitations. There is still some question with respect to *crucians*, as with respect to *punctipennis*, regarding the interpretation to be placed on its obvious avoidance of dwellings in the daytime. Whether this is due to a preference for the blood of domestic animals rather than of man and indicates a constant avoidance of dwellings, or whether it is due simply to an avoidance of dwellings *in the daytime*, after having fed on occupants of the dwellings during the night, remains to be determined.

Discussion.

There can be little doubt that in its selection of breeding places and in the physiological adaptability of its eggs and larvæ *Anopheles crucians* differs materially from *Anopheles quadrimaculatus* and *punctipennis*. Numerous observers record *crucians* larvæ developing in brackish or salt water. Howard, Dyar, and Knab (p. 1025) state that the larvæ live "usually in tidal marshes," and that "Smith in New Jersey found that the species breeds upon the salt marsh, but whether in water of saline content is not stated." They also quote Dr. Beyer as reporting that below New Orleans the adults of this mosquito constitute "an abundant pest in the salt and brackish water marshes along the lake shores east of the river, where they occur throughout the year, not even diminishing in numbers during freezing weather." Similarly, Dr. H. R. Carter in a personal communication to the writer refers to *crucians* as breeding in slightly diluted sea water at Newport News, Va., adding that no fresh water was available in the locality.

Such observations as these, together with the ones cited in the present paper, all suggest that *crucians* is attracted by water containing an excess of mineral salts. Apparently no particular type of chemical contamination is essential, for there is little in common between brackish water in tidal marshes and swamp water impregnated with sulphuric acid products.

It is even doubtful whether the attraction is limited to mineral salts, for there is some reason to believe that a concentration of organic products is equally effective. Dr. Carter, in the personal communication referred to above, cites the presence of *crucians* larvæ in pools full of decaying vegetation. The writer has observed the same thing in Florida, where even large swamps, thus characterized, appear to produce no other species of *Anopheles* than *crucians*. Such places are almost invariably full of larvæ of the genus *Uranotaenia*, which appear to thrive amid decaying vegetable matter. Frequently, however, the concentration in places of this nature becomes too great for *crucians*. The writer has found numerous instances in which this has occurred.

This relation of *crucians* to contaminated water brings up another question that should not be overlooked, in view of its possible importance in practical malaria control. Among the antimosquito measures in vogue at the present time is the use of niter cake as a larvicide. This material is a by-product (often discarded as waste) in the manufacture of sulphuric acid, and, as it happened, was one of the principal elements producing the contamination of the swamp considered in the present paper. The question at once arises, therefore, whether the use of niter cake as a larvicide is not apt to bring about a condition the opposite of that desired by inducing the breeding of *crucians* as soon as the concentration becomes low enough. The probability of this result seems sufficient to warrant considerable care in the use of niter cake.

If it were known that *crucians* is unimportant as an agent in malaria transmission, its peculiarities might serve as an aid in developing measures to combat the real culprits, but, with the present uncertainty on this point, to eradicate the others by bringing about conditions suitable to *crucians* would be to invite serious trouble.

Regarding the range of flight of *Anopheles* mosquitoes it is of interest to compare the present results with those obtained for other species. The two most satisfactory experiments on *Anopheles* flight are those recorded by Le Prince (1916 and 1917) at Panama and at two places in South Carolina. The former involved *A. tarsimaculata* Goeldi and *A. albimanus* Wied., the latter *A. quadrimaculatus* Say. The two Panama species were found to fly at least 6,250 feet, five of the forty specimens being taken at this distance, while the longest recorded flight of *A. quadrimaculatus* in South Carolina was 5,565 feet. In the latter case the results are based on four mosquitoes, one taken at 5,565 feet, two at 3,245 feet, and one at 2,800 feet from the source.

In all of these experiments the data are taken from stained specimens and represent actual flight ranges. They leave no doubt that the respective species will fly at least as far as the distances given, provided conditions are similar to those of the experiments. But do they not also indicate that in all probability these species frequently fly considerably farther? And what do they indicate regarding the proportion of individuals that reach the greater distances? From the standpoint of practical malaria control these two questions are of prime importance, and it is worth while to examine the data from this angle.

The catches of stained specimens at Panama, as given by Le Prince and Orenstein (p. 114), were the following:

2 between 1,000 and 2,000 feet.
7 between 2,000 and 3,000 feet.
0 between 3,000 and 4,000 feet.
24 between 4,000 and 5,000 feet.
2 between 5,000 and 6,000 feet.
5 at 6,250 feet.

From this it is to be observed that 12½ per cent of the recorded mosquitoes flew the maximum distance (6,250 feet), and that of those that exceeded 4,000 feet 16 per cent reached this point. Of course the numbers in the table are too small to give reliable percentages, but they are sufficient to show that a considerable proportion of the mosquitoes reached the greatest recorded distance (6,250 feet), and it can hardly be doubted that the actual flight of many individuals must have been materially greater than this, or would have been greater had there been dwellings to attract them farther. How much farther they may have flown in numbers sufficient to be of sanitary importance is a matter of conjecture, but a conservative estimate would hardly put the range at less than 7,000 feet, with a probability that some individuals would get well beyond this.

Turning to the data on *A. quadrimaculatus*, we find the following records. Of the four stained specimens captured—

1 was taken at 2,800 feet.
2 were taken at 3,245 feet.
1 was taken at 5,565 feet.

Here it is even more difficult to estimate the percentages at different distances, but since, as they stand, the figures would show 25 per cent of the mosquitoes reaching 5,565 feet, it is reasonable to suppose that a good many went materially farther.

Although these records establish definite values for the flight of individual mosquitoes, it is difficult, as just indicated, to obtain from them an answer to the primary practical question as to how far the mosquitoes fly in numbers sufficient to be of sanitary importance. To answer this question it is necessary to have records of many individuals. The most desirable data would consist of records from a large number of stained specimens, but these are not available at present. The next best evidence is that obtained from unstained specimens taken under conditions making it reasonably sure that the source of the specimens is known. Such conditions are met fairly well by the data on *Anopheles crucians* presented in the present paper. It is not certain that the source of every mosquito recorded in these data is known, but it is certain that the great bulk of the specimens are from one place (the swamp), and since we are not concerned with the individual extreme records so much as with the general distribution, the facts justify certain tentative conclusions.

Summary of Flight Records.

In Table 2 is presented a summary of the records.

TABLE 2.—*Showing the average number of specimens of Anopheles crucians per station (group of buildings) at graduated distances from the swamp.*

Distance (feet).	Total number of specimens.	Number of stations.	Number of specimens per station.
0 to 1,000	257	6	43
1,000 to 2,000	92	6	15
2,000 to 3,000	52	6	9
3,000 to 4,000	124	11	11
4,000 to 5,000	10	2	5
5,000 to 6,000	10	6	2
6,000 to 7,000	59	12	[1] 5
7,000 to 8,000	15	16	1
8,000 to 9,000	12	6	2
9,000 to 10,000	3	10	$\frac{3}{10}$
Over 10,000	....	3	....

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[1] The large numbers here are due to the catch at station 9S (see Table 1), a particularly favorable place near the ditch carrying the chemical wastes.

From this it may be seen that at more than 9,000 feet the catch averaged less than one specimen to every three groups of buildings. Between 9,000 and 7,000 feet it averaged between one and two specimens per group of buildings—22 groups yielding 27 specimens. It is only at a distance of 7,000 feet or less that the numbers are great enough to be of definite importance.

Comparing this with the conclusions drawn provisionally from the experiments of Le Prince with stained mosquitoes it is seen that they are in relative agreement in indicating a flight of approximately 7,000 feet in numbers sufficient to be important. In practical anti-malaria work, therefore, it would appear justifiable to control a zone approximately 7,000 feet wide around the area to be protected, increasing or decreasing the distance according to special local conditions.

This, of course, may not apply to species other than those studied. For instance, in the eastern United States *Anopheles punctipennis* may not conform to the range of flight of *quadrimaculatus* and *crucians*, although it probably does not deviate far from it.

With respect to the importance of *crucians* as an agent in malaria transmission there is little to add to what has already been said. Its habits would indicate that it is not so important as *quadrimaculatus*, although it may be more important than *punctipennis*. This question is being studied by the writer at the present time.

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TREATMENT AND DISPOSAL OF CREAMERY WASTES.

By Earle B. Phelps, Professor of Chemistry, Hygienic Laboratory, United States Public Health Service.

An experimental investigation of the treatment and disposal of creamery wastes was carried out during the years 1916–17 by the United States Public Health Service, cooperating with the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture.[1] This investigation was carried out at the plant of the

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[1] This investigation was in immediate charge of Sanitary Engineer H. B. Hommon, United States Public Health Service, who is responsible for its general plan and direction. He was assisted in the design and construction by Sanitary Engineer H. R. Crohurst and, during the period of operation, by Sanitary Chemist H. P. Corson, in resident charge. Mr. L. A. Rogers, Bacteriologist, in Charge of Research Laboratories, Dairy Division, cooperated throughout and lent helpful assistance. The work of preparation of a complete report was interrupted by the advent of the war, and Mr. Hommon is now serving in France as a captain in the Sanitary Corps, United States Army. This preliminary presentation of methods and results is made, because of a considerable demand for information upon the subject and in order to make the results of the investigation promptly available. It is intended to publish the complete report at some later date.